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Diagnostic Value of Diffusion-Weighted - MRI in the Characterization of Vaginal Masses

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Abstract

Background: Carcinoma of the vagina is relatively one of the rare gynecological malignancies. It is considered a predominant disease of post-menopausal women. Secondary vaginal cancers are much more common. It can be either due to direct extension from adjacent organs or from distant metastasis. Pelvic examination is the primary evaluation method, yet it has many limitations. Hence cross-sectional imaging is recommended for the delineation of tumor extension that eventually will affect the management of the disease.

Aim of Study: This study aimed to evaluate the role of conventional MRI, contrast-enhanced MRI (CE MRI), and diffusion-weighted imaging (DWI) in the characterization of vaginal masses.

Patients and Methods: Twenty female patients were enrolled in the current study. They presented with vaginal masses that needed further MRI examination for characterization and diagnosis.

Results: This study showed that DWI was higher in specificity and sensitivity in the differentiation between malignant and benign vaginal masses.

Conclusions: Pelvic MRI examination is considered a very effective imaging tool for local assessment of vaginal lesions to show extensions and nodal metastasis moreover, in conditions where contrast media is contraindicated, DWI can help in the differentiation between malignant and benign vaginal masses.

Key Words: *Vaginal cancer – T2WI – DWI – Squamous cell carcinoma.*

Introduction

VAGINAL primary cancer is an uncommon illness, representing about 1-3% of all gynecologicalcancers. The prevalence of primary vaginal cancer rises with age, 20% of patients are over 80 years old, while about 50% of patients present at an age over 70 **[1].**

Many risk factors were encountered, such as HPV, smoking, infections, multiple sexual partners, vulvarlichen sclerosis, and previous radiotherapy for cervical cancer **[2].**

Secondary cancers are far more common.It represents about 80%-90% of all malignancies of the vagina. It might be due to direct spread from the adjacent organs like the colon, rectum, urinary bladder, uterus, vulva, and cervix or can be from distant metastases via lymphatics or a blood route from the kidney, stomach, ovary, or breast **[2].**

Among histological subtypes, squamous cell carcinoma (SCC) is the most prevalent. It encompasses approximately 85%. The second most common is adenocarcinoma (5 to 10%). Other subtypes include melanomas, lymphomas, and sarcomas **[3].**

Vaginal bleeding is the most typical clinical symptom of vaginal cancer. Other possible symptoms can result from the direct spread of the disease, such as tenesmus or urinary frequency. Though, at the time of diagnosis, 10% of women with vaginal cancer are asymptomatic and a Pap test or physical examination is the only way to identify their vaginal cancer **[4].**

Pelvic exams remain the main method for determining the severity of the condition. Nevertheless,

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List of Abbreviations:

HPV : Human papilloma virus.
SCC : Squamous cell carcinoma.
CE MRI: Contrast-enhanced MRI.
DWI : Diffusion-weighted imaging.
RMS : Rhabdomyosarcoma.

it has some drawbacks, such as the inability to identify lymph node metastasis and the difficulty of determininginfiltration of the surrounding tissues. As a result, FIGO 2009 advises using cross-sectional imaging techniques like CT or MRI scanning **[5].**

MRI is thought to be the best method for determining the local (pelvic) tumor extension **[6].**

Aim of the work:

The purpose of the study was to assess the value of conventional MRI, contrast-enhanced MRI (CE MRI), and diffusion-weighted imaging (DWI) with ADC mapping in the characterization of vaginal masses.

Patients and Methods

Patients:

The following study type was a prospective one. It was carried out for a period of twenty-four months. It was conducted in the radiology department at National Cancer Institute and Kasr Al-Ainy Hospital in the period between 2022 and 2023. All included patients gave written consent. The ethical committee at our university approved our study.

The study included 20 patients; They were between the ages of 15 and 79, with a mean age of 54 and a median age of 64. Patients enrolled in our study were female patients who presented with vaginal masses either detected by clinical examination or ultrasonography.

Ultrasound examination: Transvaginal ultrasonography was done for all patients (except for two patients who were virgins). The patients were asked to empty the urinary bladder before the start of the examination. A transvaginal probe was used with a frequency of 7–8 MHz. The vagina was scanned, and the lesions were classified into cystic or solid, unilocular or multilocular if cystic, and echogenicity in solid tumors, margins, and relations to surroundings. The vascularity was assessed by color Doppler study using the IOTA score: A color score of 1 was given in cases with no detectable blood flow, a color score of 2 if minimal blood flow was detected, a color score of 3 if moderate blood flow was detected, and a color score of 4 in cases with rich blood flow **[7].**

Eventually, further MRI examination was planned for characterization and diagnosis. The study excluded patients with contraindications to MRI contrast media as patients with renal failure or patients with allergy to contrast media.Otherpatients who were unable to perform an MRI examination, e.g. patients who are claustrophobic or with metallicpacemakers, were excluded from our study.

MR imaging: A high-fieldclosed magnet system (1.5 Tesla) (Phillips Achieva XR) was utilized to perform MR imaging. Patients were asked to lie in the supine position. An antecubital vein was used to insert a venous catheter that is connected to an automated injector. To decrease intestinal peristalsis, an antispasmodic medication (10mg of visceralgine) was injected intravenously just prior to MR imaging. Conventional MRI, DWI, and post-Gadolinium MR imaging were carried out.

Every patient underwent the subsequent magnetic resonance sequences:

- Survey.
- Multi-planar MR imaging sequences before contrast including:
  - Sagittal, coronal, and axial T2WI.
  - Axial T1WI.
  - Fat-suppressed images.
- Gadolinium-enhanced T1-weighted sequences (post-contrast T1 fat sat thrive).
- DWI with multiple b-values (0/ 300 /600).

MRI images were reviewed regarding the morphological features including size, shape, signal intensity, extensions, relations, signal intensities, and pattern of enhancement. Afterward, the diffusion images were reviewed for final radiological characterization. Two qualified radiologists individually examined the images with an average of 4 and 9 years of experience.

To perform the DWI analysis, we first created the ADC map and then manually chose the ROI. The ADC value has been calculated automatically. By using the MR conventional sequences as a guide, the lesion was identified on DWI and ADC maps. The lesion's signal intensity on DWIs was assessed (qualitative assessment and quantitative assessment with ADC map).

Statistical analysis: The social sciences statistical software (SPSS) version 26 (IBM Corp., Armonk, NY, USA) was utilized for coding and entering the data. As for quantitative data, the mean, standard deviation, median, minimum, and maximum were used; for categorical data, the frequency (count) and relative frequency (%) were employed to compile the information. The non-parametric Mann-Whitney and Kruskal-Wallis tests were employed for the comparison of quantitative variables. (Chan, 2003a).

We used the Chi-square (χ^2) test when comparing categorical data. When the predicted frequency was less than 5, the precise test was performed instead (Chan, 2003b). *p*-values were regarded as statistically significant if they were less than 0.05.

Chan YH (2003a): Biostatistics 102: Quantitative Data – Parametric & Non-parametric Tests. Singapore Med J., 44 (8): 391-396.

Chan YH (2003b): Biostatistics 103: Qualitative Data –Tests of Independence. Singapore Med J., 44 (10): 498-503.

Results

There were twenty female patients in the study's sample population. They were presented with vaginal masses either by clinical examination and/or ultrasonography. They were between the ages of 15 and 79, with a mean age of 54 and a median age of 64. Ultrasonography was done for all patients (TVUS for 18 patients and pelvic US for 2) and classified the lesions into two groups. Benign-looking lesions were two unilocular cystic lesions and three solid lesions. All benign-looking lesions had a color score of 1-2. The other group was the malignant-looking group (fifteen lesions). They were solid lesions and showed high vascularity with a color score of 3-4. The deep extensions and the relations to the surrounding structures were limited in the US examination. So pelvic MRI was scheduled for all patients. Histopathological confirmation was done for the patients. Fifteen cases were proven to be malignant compared to 5 benign lesions.

The patients' histopathological diagnoses that were part of our research were as shown in (Table 1). Six patients were squamous cell carcinoma (Fig. 1) (30%), three were melanoma (Fig. 2) (15%), two were vaginal leiomyoma (10%), two were vaginal cysts (Fig. 3) (10%), two were angiomyxoma (Fig. 4) (10%), one was vaginal polyp (5%), one was rhabdomyosarcoma (5%), one was adenocarcinoma (5%), one was malignant mixed mullerian tumor (5%) and one was recurrent cervical cancer (5%). Out of the 20 patients: 15 (75%) patients were considered malignant compared to 5 (25%) patients who were benign.

Table (1): Histopathology of the vaginal masses.

	Count	%
Histopathology of vaginal masses:		
Vaginal polyp	1	5.0
Vaginal leimyoma	2	10.0
Vaginal cyst	2	10.0
Squamous cell carcinoma	6	30.0
Rhabdomyosarcoma	1	5.0
Recurrent cervical cancer	1	5.0
Melanoma	3	15.0
Recurrent malignant mixed mullerian tumor	1	5.0
Angiomyxoma	2	10.0
Adenocarcinoma	1	5.0

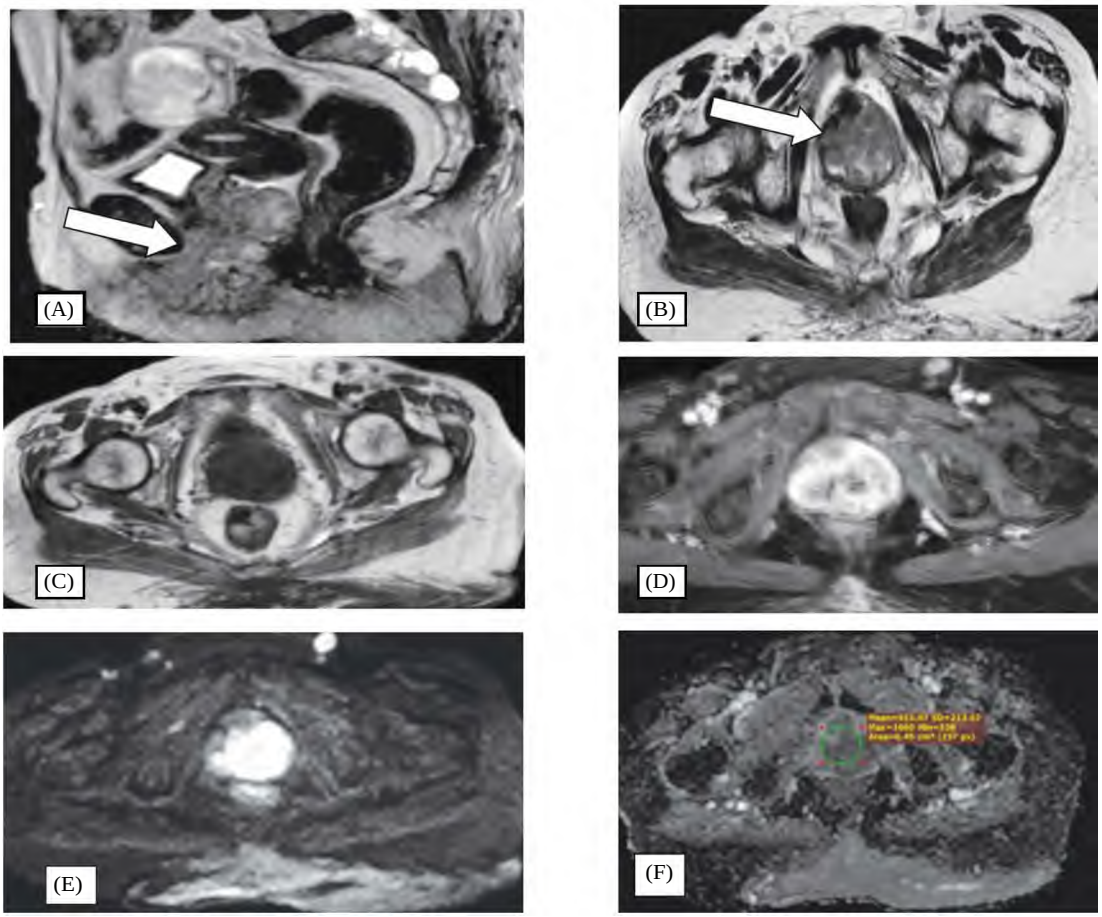

Fig. (1): A 68-year-old female presenting with vaginal bleeding. sagittal T2WI. (A) Axial T2WI (B) and axial T1WI (C) Images revealing large infiltrating vaginal lesion eliciting low signal in T1WIs and high heterogeneous signal in T2WIs. The mass is seen infiltrating the lower urethra. Post-contrast (D): It shows heterogeneous enhancement. DWI and ADC image. (E,F) The mass is restricted on DWIs with low ADC. ADC value was (0.915×10^{-3} mm^2/s). The lesion was pathologically proven SCC of the vagina.

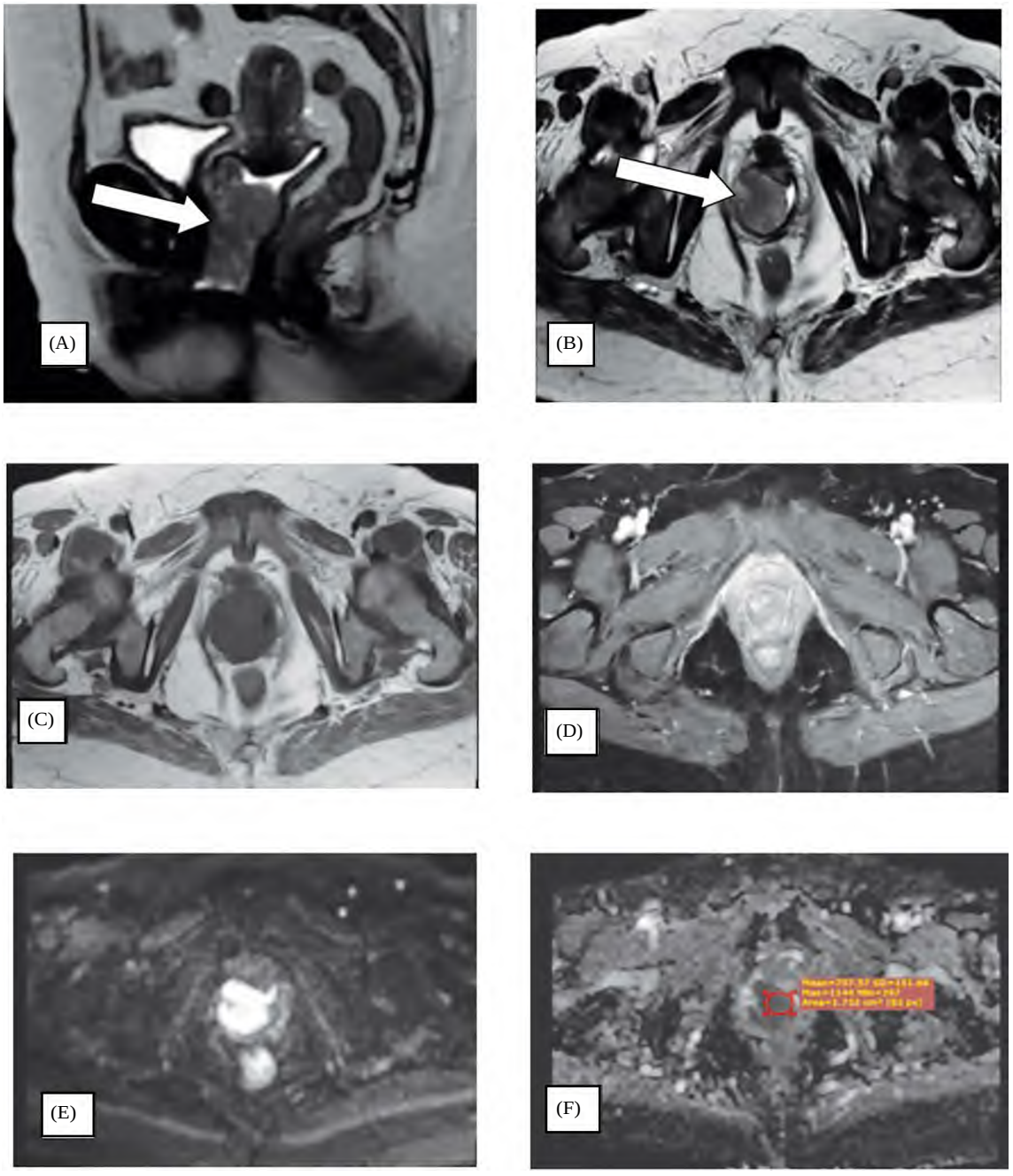

Fig. (2): A 79-year-old female presenting with vaginal bleeding and pain. Sagittal T2WI (A) Axial T2WI (B) and axial T1WI. (C) Images reveal the vagina is distended with soft tissue lesion extending to the anterior fornix eliciting iso-intense signal in T1WIs and high heterogeneous signal in T2WIs. Yet there is a free bladder wall. Post-contrast. (D) It shows homogenous avid enhancement. DWI and ADC image. (E,F) The lesion shows a high signal on DWI and a low signal on the corresponding ADC maps. ADC value was (0.707×10^{-3} mm^2/s). The pathology was melanoma of the vagina.

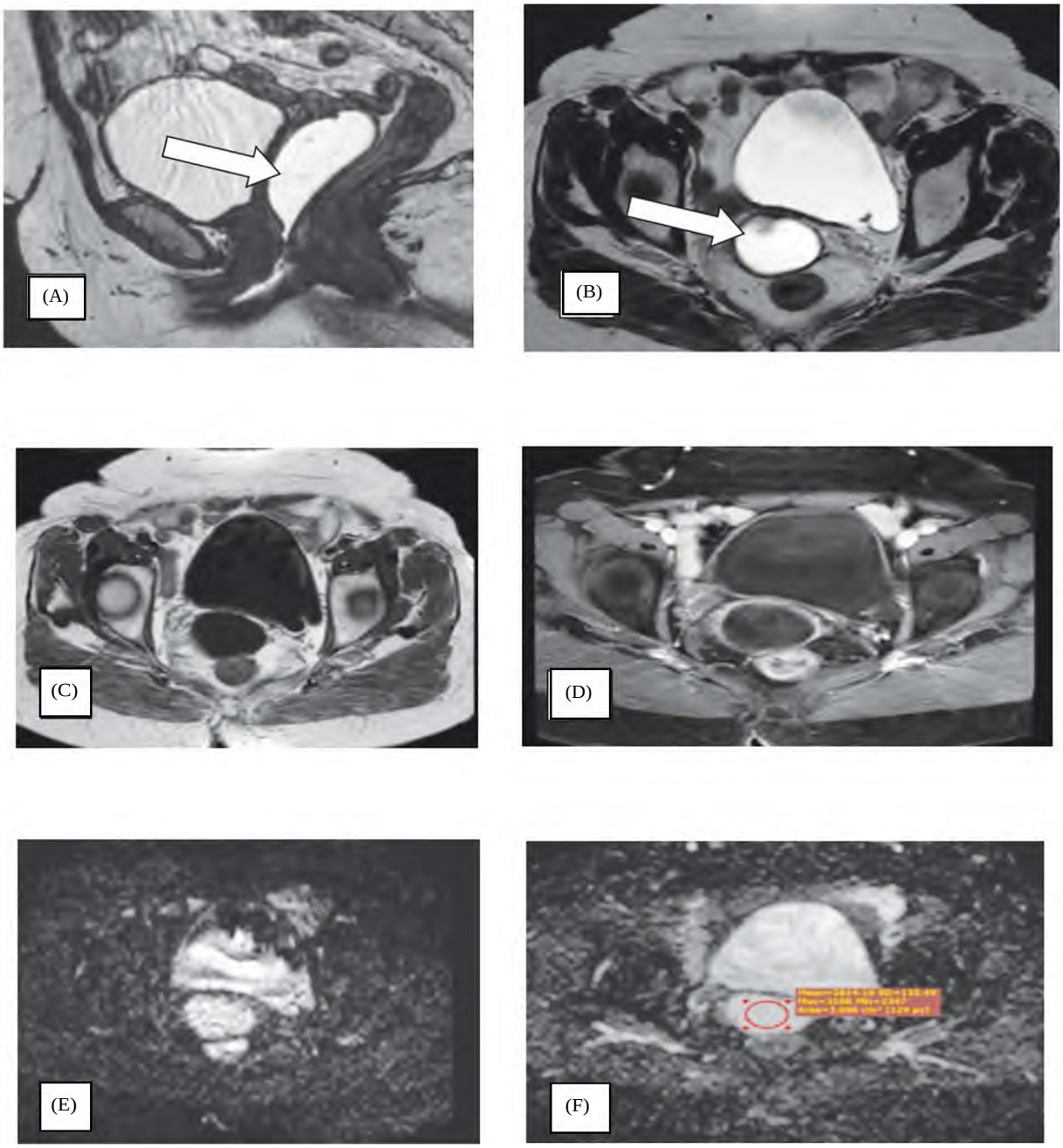

Fig. (3): A 62-year-old female. Presented with pelvic heaviness. sagittal T2WI. (A) Axial T2WI (B) and axial T1WI. (C) Cystic vaginal lesion is seen eliciting low signal in T1WIs and high signal in T2WIs. Post-contrast. (D) It shows no enhancement. DWI and ADC image. (E,F) The lesion shows a high signal on DWI and a high signal on the corresponding ADC maps (T2 shine through). ADC value was (Mean 2.8 x 10^{-3} mm^2/s). The pathology was a simple benign cyst of the vagina.

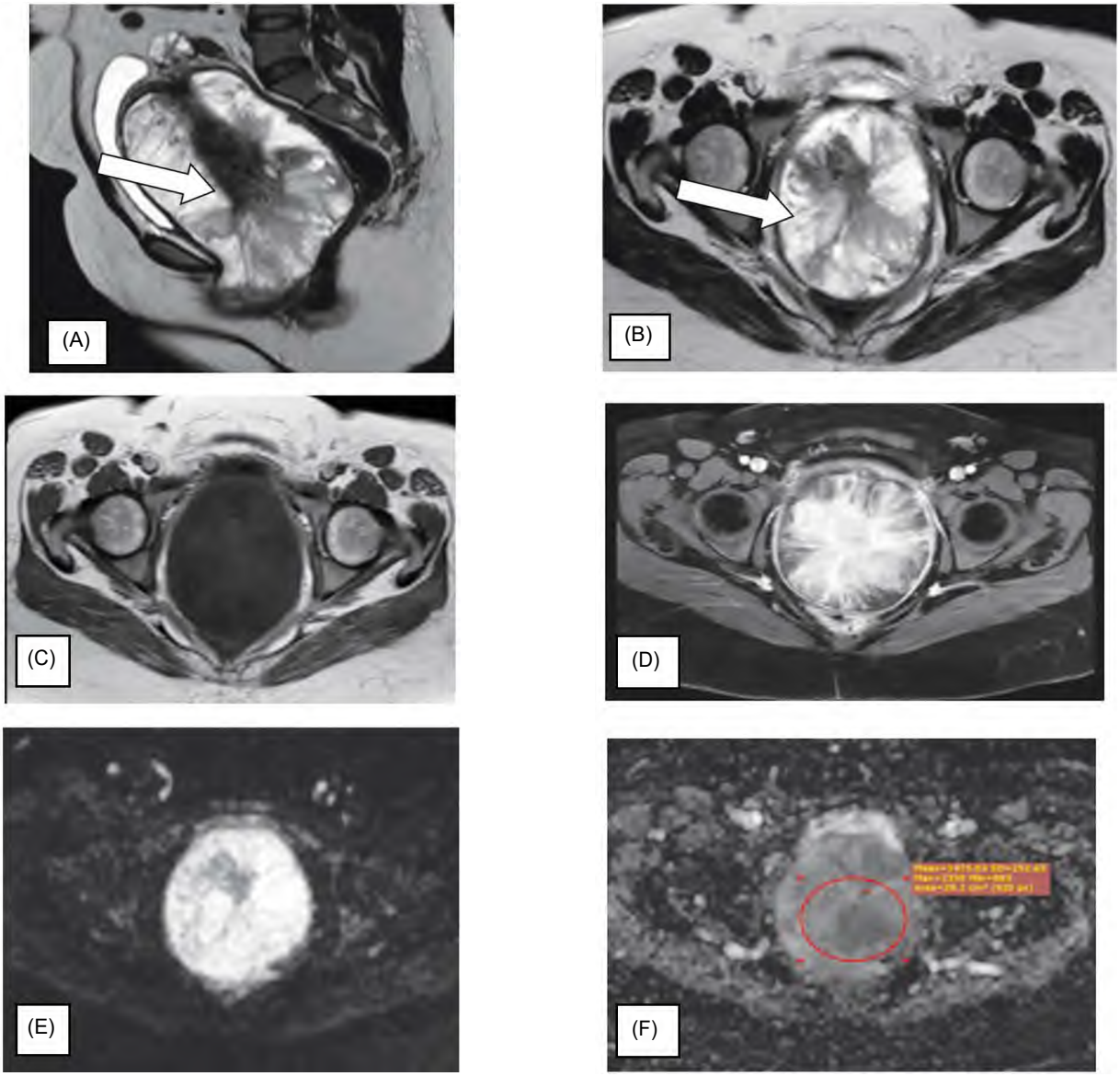

Fig. (4): A 32-year-old female presented with vaginal mass and pain. Sagittal T2WI. (A) Axial T2WI. (B) and axial T1WI. (C) Showing huge vaginal mass distending the vagina and vaginal fornices eliciting low heterogeneous signal in T1WIs and high heterogeneous signal in T2WIs. The mass is seen stretching the urinary bladder and rectum with no extra vaginal extension. Post-contrast. (D) It shows heterogenous enhancement with swirled pattern. DWI and ADC image. (E,F) The lesion shows a high signal on DWI and a low signal on the corresponding. ADC maps. ADC value was (1.4×10^{-3} mm^2/s). It was proven vaginal angiomyxoma.

Regarding Conventional MRI examination: In our study, we found most of the malignant tumors (n=11) (73.3%) had high signal on T2WIs with a *p*-value of 0.016. (statistically significant) (Table 2).

The pattern of contrast enhancement in our cases did not show statistical significance between the benign and the malignant groups. Avid contrast enhancement was detected in 3 benign cases (out of the 5 benign cases) and 11 malignant cases (out of the 15 malignant cases) as seen in (Table 3).

Regarding DWI and ADC mapping: Included patients underwent DW imaging with qualitative and quantitative image assessment. The qualitative DWI revealed restricted bright signal with high *b*-values of 100% of malignant vaginal lesions when compared to the normal adjacent muscles. And no restriction in 100% of benign tumors. With a significant *p*-value of 0.001 (Table 4).

For each case of vaginal masses quantitative DWI and ADC mapping were performed, along with a thorough examination of ADC (mm^2/sec) values shown in (Table 5).

Table (2): Shows the signal intensity of the lesions in conventional MRI sequences.

	Benign (5)		Malignant (15)		*p*-value
	Count	%	Count	%	
T1:					
Hyper intense	1	20.0	0	0.0	0.105
Hypo intense	1	20.0	8	53.3	
Iso intense	3	60.0	6	40	
Mixed	0	0.0	1	6.6	
T2:					
Hyper intense	1	20.0	11	73.3	0.016
Hypo intense	3	60.0	0	0.0	
Iso intense	1	20.0	2	13.3	
Mixed	0	0.0	2	13.3	

Table (3): The pattern of contrast enhancement on MRI.

	Benign (5)		Malignant (15)		*p*-value
	Count	%	Count	%	
Contrast pattern:					
No Contrast	2	40.0	0	0.0	0.063
Homogenous	3	60.0	8	53.3	
Heterogenous	0	0.0	7	46.3	
Contrast:					
No contrast	2	40.0	0	0.0	0.112
Avid	3	60.0	11	73.3	
Minimal	0	0.0	4	26.6	

Table (4) Shows the signal of the lesions in DWIs and ADC.

	Benign (5)		Malignant (15)		*p*-value
	Count	%	Count	%	
DWI:					
Hyper intense	1	20.0	15	100.0	0.001
Hypo intense	4	80.0	0	0.0	
ADC:					
Hyper intense	5	100.0	0	0.0	0.001
Hypo intense	0	0.0	15	100.0	

Table (5): Shows the mean, median, and standard deviation of the ADC values among the studied groups.

	Benign	Malignant	*p*-value
ADC value:			
Mean	2.50	1.07	0.062
Standard Deviation	0.42	0.35	
Median	2.50	1.01	

Our study showed that the DWI sequence was higher in specificity and specificity than the T2WI sequence while differentiating benign from malignant vaginal masses (Chart 1).

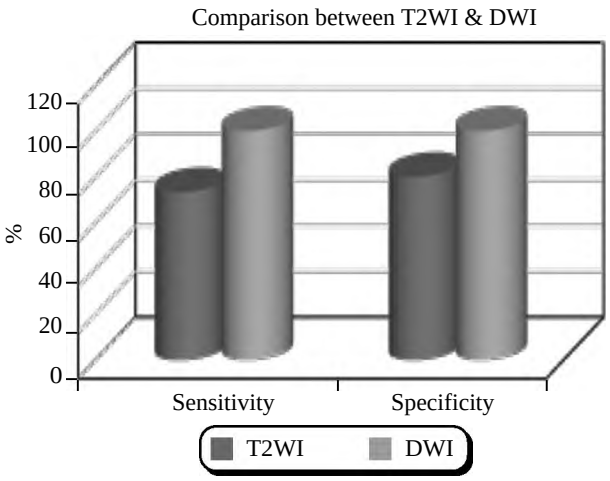

Chart (1): Comparison between the DWI and T2WI.

Regarding the relation to the adjacent structures and nodal metastasis, out of 15 malignant cases, 7 cases (46.6%) showed invasion of adjacent structures. And 5 cases (33.3%) show nodal metastasis (Table 6).

Table (6): Shows the relation to the surrounding structures and nodal metastasis among the studied group.

	Benign (5)		Malignant (15)		*p*-value
	Count	%	Count	%	
Relation to adjacent structures:					
Invasion	0	0.0	7	46.6.8	0.080
No invasion	5	100.0	8	53.3	
Nodal metastasis:					
Yes	0	0.0	5	33.3	0.208
No	5	100.0	10	66.6	

Discussion

Approximately 3% of all malignant neoplasms of the female genital tract are primary vaginal cancers. The majority of vaginal cancers occur in postmenopausal or elderly women **[8]**.

Although transvaginal ultrasound examination usually represents the first diagnostic method used in gynecological diseases, it has many limitations. It is an operator-dependent technique and mightbe not feasible, especially in post-operative patients or in cases with large lesions obstructing the vagina or if the patient is a virgin **[9]**.

Moreover, it does not offer a panoramic overview or cross-sectional planes. similar to an MRI

[9]. Consequently, FIGO 2009 suggests using cross-sectional imaging (CT/MRI), especially for the detection of metastatic lymph nodes and for better assessment of tumor extensions *[5]*.

This study included 20 patients. The median age was 64 years which approaches the median age stated by Taylor et al., *[10]* which was 54 years, and the median age stated by Gunderson et al., *[11]* was 60 years.

This study included 15 malignant vaginal tumors, the other five lesions were benign. The most frequent pathological type of vaginal tumor was SCCwhich was similar to Lima et al., *[5]* who reported that 77.1% of patients had SCC, which represents the most common histological subtype. Gunderson et al., *[11]* stated that 73% of patients had squamous cell carcinoma as well.

In our study, we found most of the malignant tumors (13/15) (86.6%) had high signal in T2WIs. which was like Taylor et al., *[10]* who stated that 92% of the malignant vaginal tumors had high signal on T2WIs. Also, according to Gardner et al., *[1]*, a tumour exhibits a higher signal intensity on T2-weighted images than fibrosis, which has a lower signal on T2WI.

This study showed DWI restriction in all malignant group compared to no restriction in the benign group. Zulfiqar M. et al., *[2]* also noted restricted diffusion and low ADC values in the malignant vaginal lesions.

This study also showed that the specificity and sensitivity of DWI was higher than T2WI in the differentiation between benignand malignant vaginal lesions. All malignant tumors show restriction on diffusion-weighted images and low signal on the ADC map. We also found that there was no diffusion restriction among the benign group.

The diagnostic impact of MRI T2WI sequence and DWI have been studied in the literature on gynecological tumors. A study done by Neves T.R et al., *[12]* stated that: In endometrial cancer, a combination of T2WI & DWI is the best in increasing the sensitivity of MRI, especially for the detection of myometrial invasion.

Also, Haldorsen I.S. et al., *[13]* mentioned in their study done on cervical cancer, that DWI is better than T2WI, especially in size detection and parametrial extension.

Regarding solid ovarian tumours, low T2WI and high DWI are noticed in benign tumors as stated by Türkoğlu S. et al., *[14]* unlike intermediate to high T2WI and high DWI is seen in malignancy so a combination of the two sequences is important for proper interpretation.

As for the MRI appearance of vaginal tumors in our study, we had 3 cases of melanoma showing an isointense signal on T1WIs and a high signal on T2Wis. This doesn't match Liu et al., *[15]* who stated that the hyperintense signal was appreciatedon T1WI and the hypointense signal appreciated on T2W imaging, which are typical MRI features.

This may be due to the difference in melanin concentration as (Liu et al., 2015) claimed that the melanin concentration affects the signal of the melanoma in MRI sequences *[15]*.

In our study, we had a case of angiomyxoma that showed a heterogenous low signal on T1WIs and a heterogeneous high signal on T2WIs with a swirled pattern of enhancement which is consistent with Eckhardt et al., *[16]*.

Limitations:

The prevalence of vaginal tumors is somehow not common. So, we currently included a relatively small number of cases in this study. We recommend further studies with greater sample sizesto emphasize the diagnostic role of MRI in their diagnosis.

Conclusions:

Although pelvic examination and transvaginal ultrasonography are the primary methods for the assessment of vaginal masses, they have some limitations. Pelvic MRI examinationisa very effective imaging tool for local assessment of vaginal masses to show extensions and nodal metastasis moreover, in conditions where contrast media is contraindicated,the distinction between benign and malignant vaginal masses can be made with the use of DWI.

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القيمة التشخيصية للتصوير بالرنين المغناطيسى بالانتشار فى توصيف الكتل المهبلية

تعتبر اورام المهبل نادرة حيث تمثل ١–٣ ٪ من اورام امراض النسا ويزيد معدل حدوث اورام المهبل مع التقدم فى العمر حيث ان ٥٠٪ من المرضى فوق سن السبعين و٢٠٪ من المرضى فوق سن الثمانين.

اشتملت هذه الدراسة على ٢٠ مريض منهم ١٣ مريض يعانون من اورام خبيثة و٥ مرضى يعانون من اورام حميدة ومريضان يعانون من الاورام العدوانية محليا.

و تهدف هذه الدراسة لتقييم دور الرنين المغناطيسى العادى والرنين المغناطيسى المعزز بالصبغة والتصوير المغناطيسى الانتشارى الكمى مع تعيين قيمة معامل الانتشار الظاهرى فى تقييم اورام المهبل.

تم التصوير بالرنين المغناطيسى الانتشارى باستخدام ثلاثة قيم تشمل (٠ و٣٠٠ و٦٠٠) مم مربع / الثانية وتم احتساب معامل الانتشار الظاهرى عن طريق قياس معاملات نفس الصور عند قيم مختلفة وتمثيله كخريطة لمعامل الانتشار الظاهرى والتى منها تم قياس معاملات الانتشار الظاهرى.

اظهرت هذه الدراسة ان أكثر نوع من اورام المهبل الاولية هو سرطان الخلايا الحرشفية.

اظهرت النتائج التى توصلنا اليها ان اضافة الرنين المغناطيسي المعزز بالصبغة لم ينتج عنه تحسنا ذو دلالة احصائية قوية في تقييم اورام المهبل. استخدام الرنين المغناطيسى بالصبغة متعدد المراحل ورسم منحنيات الصبغة كان سيكون مفيدا فى تحديد نمط اخذ الصبغة وتركها فى الاورام للتفرقة بين الاورام الحميدة والخبيثة.

اظهرت نتائج الدراسة ان اضافة التقييم الكمى والكيفى لخرائط معامل الانتشار اضافت ١٠٠٪ تفرقة نوعية فى التفريق بين الاورام الحميدة و الخبيثة.